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A study on the timing for providing information affecting the evacuation decision-making at flooding

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Abstract

Along with global warming, extreme weather event has been pointed out. In Japan, flood that exceeds the plan scale is increasing. The flood control policy in Japan of the river basin, not only do they need a structural measure, but also non structural measure that lead to evacuation by conveying the proper information.

Hazard map is one of the non-structural measures and it can prompt to evacuate. In September 2015 Kanto-Tohoku heavy rain, the Kinugawa river in Joso city is flooded. Even if the anticipated flooded areas of the hazard map are almost the same as the actual flooded areas, about 4300 residents in Joso could not evacuate and isolate their home [1]. The fact is that non-structural measures can be effective if only residents properly understand and use them [2]. To minimize human suffering in flood zone, we need to reveal the actual situation of the evacuation and to improve non-structural measures.

In this research, we analyzed the actual situation of evacuation at the time of flood and the effects of past flood experience on evacuation decision-making at flooding by conducting a hearing survey at the inundation assumption area of Yuragawa river running through Kyoto Fukuchiyama (the flood occurred in 2013 and 2014). Furthermore, we conducted similar hearing survey in the inundation assumption area of Kinugawa river running through Ibaraki pref. Joso. And we compared disaster awareness in Fukuchiyama and that of Joso. And we analyzed the relationship between the awareness of hazard map and evacuation behavior.

From here on, in order to examine the necessary information and the best timing for evacuation, we are planning to carry out the flood analysis that takes into account the tributaries in addition to the main river.

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1. Past flood experiences in Fukuchiyama and Joso

In Fukuchiyama, flood occurred 10 times in 50 years. In hearing survey, we focus the flood in 2013 and 2014. These flood occurred 2 years in a low.

In Joso, flood that levee of Kokaigawa river collapse is occurred in 1986, then flood that levee of Kinugawa river collapse is occurred in 2015. And the most part of Joso city was inundated and about 4300 residents had failed to evacuate and called for rescue.

In summary, Flood in Fukuchiyama occurred 2 years in arrow, and Flood in Joso occurred 30 years ago.

2. Previous study on relationship between flood experience and evacuation

The previous study on the effect of flood experience on disaster awareness and disaster prevention behaviour reported by Katada [3] is that "The residents who has flood experience tend to be high disaster awareness.". Otherwise, Takao [4] reported that "Flood experience is not associated with disaster prevention behaviour." In this research, we analyse about the effect of flood experience on evacuation decision-making. And we compared disaster prevention conscious in Fukuchiyama where flood occurred in the previous year and that of Joso where flood occurred in 30 years.

3. The current state of hazard map

Hazard map that is predicted to flood and evacuation site on the anticipated inundation area map is one of the non-structural measures. In 1994, construction ministry started to make this map. In revise of the flood control act in 2001, municipality was required an obligation that they make efforts to tell residents about information of evacuation and flooding risk and hazard map become the effective way to achieve that [5]. And revise of the flood control, act in 2005, hazard map includes not only conventional flood forecasting, but also flood forecasting considering the main medium and small size rivers, and the municipality was required the use of hazard map that make residents can know evacuation sites or flood inundation areas [6]. The purpose of Hazard map is to minimize of human suffering by smooth evacuation and enhancement of disaster prevention awareness [7][8]. The lack of information that guides residents to evacuate from the flood on this map was crucial to be improved. Improvement of hazard map is insufficiency of information that residents should evacuate where and which route [9].

4. Investment method

We conducted a hearing survey on 29 August 2015 to 30 August 2015. Target area is anticipated inundation areas of Yuragawa river in Fukuchiyama. And the target events are the flood occurred by typhoon 18 in 2013 and the flood by heavy rain of Fukuchiyama in 2014. Our survey was about 1 or 2 years later after the flood disaster occurred in Fukuchiyama city. We asked about inundation situation and evacuation situation, etc. The hearing way is home visit and we asked face to face some questions. We got 215 answers.

Next survey, we conducted similar a hearing survey on 21 November 2015 to 23 November 2015. The target area is inundation areas of Kinugawa river in Joso. And Target event is flood by Kanto-Tohoku heavy rain in September 2015. We asked about inundation situation and evacuation situation, etc. The hearing way is home and shelter visit and we got 215 answers. The attributes of hearing survey is the family structure and the age. Fig.1 shows the family structure of a hearing survey in Fukuchiyama, and Fig.2. shows the family structure of hearing survey in Joso. Next,

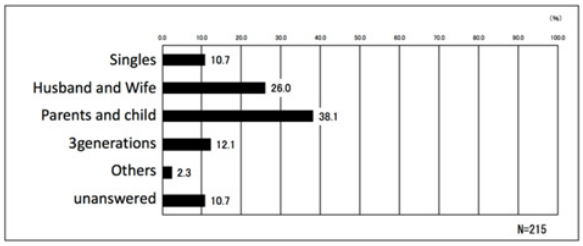

Fig. 1. The family structure of hearing survey in Fukuchiyama.

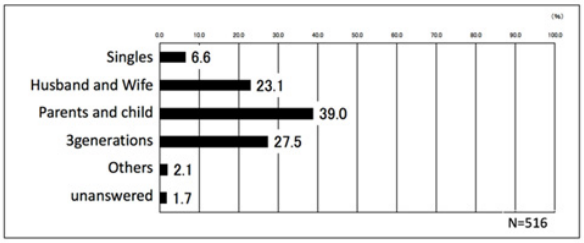

Fig. 2. The family structure of hearing survey in Joso.

Fig.3 shows the age of a hearing survey in Fukuchiyama, and Fig.4 shows the age of hearing survey in Joso.

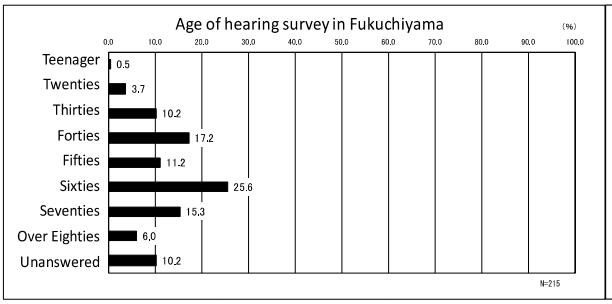

Fig. 3. Age of hearing survey in Fukuchiyama.

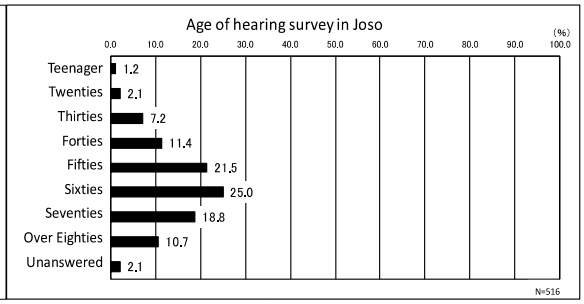

Fig.4. Age of hearing survey in Joso.

5. Investigation results

5.1 Flood experience and evacuation decision-making situation in Fukuchiyama

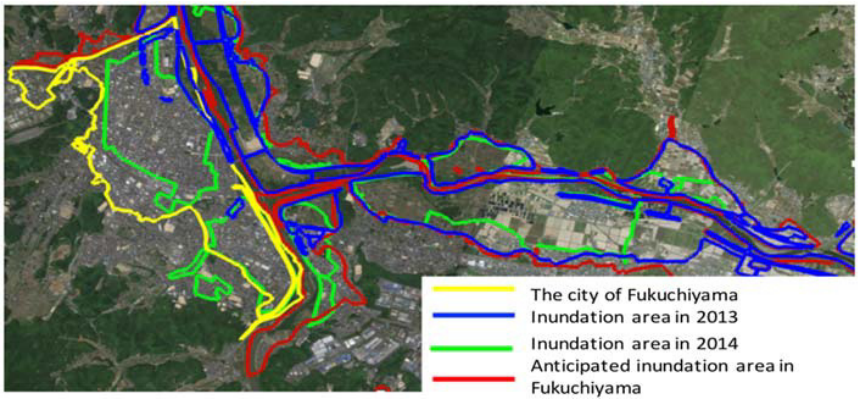

Fig. 5. Area of investigation in Fukuchiyama.

Fig.5 shows that the area lined with yellow is Fukuchiyama city area. In 2013, there was a small flood in this area, then in 2014, there was a large flood happened again, which led this area to be covered with floods. Therefore, we analyzed the effect of flood experience on evacuation judgment. Specifically, we indicate the relationship between the question “Did flood experience in 2013 affected evacuation decision-making in 2014?” and “Evacuation situation in 2014 (Did you evacuate for shelter or stayed at home?)” and Fig.6 shows the relationship.

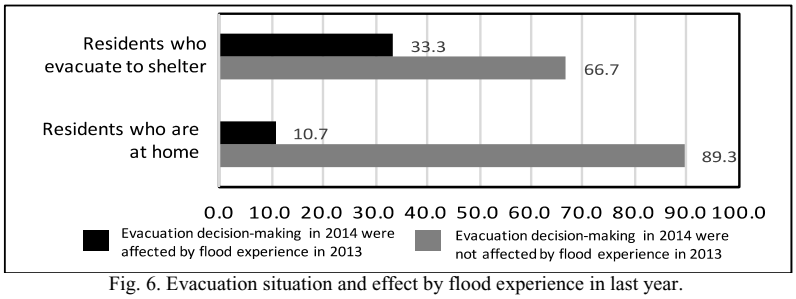

Fig. 6. Evacuation situation and effect by flood experience in last year.

And we conducted chi-square test and there is a significant difference between two questions ($\chi^2 = 4.470, df = 1, p < .05$). χ^2 is chi-square value, df is flexibility, $p < .05$ means significant level is 5 %.

In consequence, residents who answered "Evacuation decision-making in 2014 was affected by flood experience in 2013." tend to evacuate to shelters rather than to stay at home. And Fig.7 shows the reason why residents decided to evacuate at the time of flood of 2014 in Fukuchiyama.

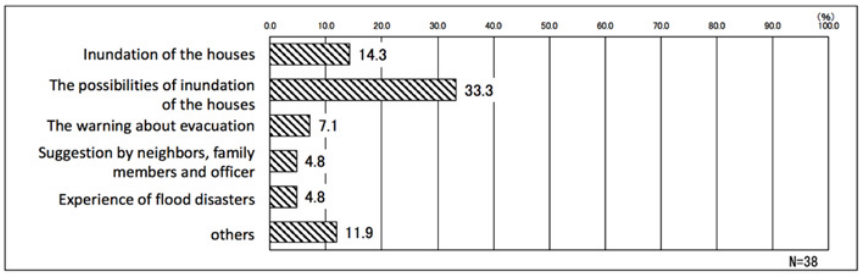

Fig. 7. Trigger of evacuation in Fukuchiyama.

From the results, we can understand that the most numerous reason why those residents, who answered "Evacuation decision-making in 2014 were affected by flood experience in 2013.", evacuate to shelter is "The possibilities of inundation of the houses" (about 33%). Therefore, residents who answered "Evacuation decision-making in 2014 was affected by flood experience in 2013." tend to evacuate before flooding because they thought house was going to be inundated.

5.2. Recognition of residents for flood

Fig.8 shows that comparison of the awareness of the hazard map between Joso residents and the ones in Fukuchiyama. Whether the residents in Joso and Fukuchiyama know the Hazard map in their daily life. 20% of the residents in Fukuchiyama do not know about the hazard map. Thus the majority of the residents in Fukuchiyama tend to check the hazard map. On the other hand, 61% of the residents in Joso do not know about the hazard map, it means most of the residents in Joso do not check the hazard map. From hearing for Joso city office, they said that they distributed the copies of the hazard map to all residents when they first made its hazard map in 2009, however, the residents could not fully understand the map because the city office did not provide any help, such as events. From the statements above, the residents in Joso clearly did not know about the hazard map and they could not utilize them practically and properly.

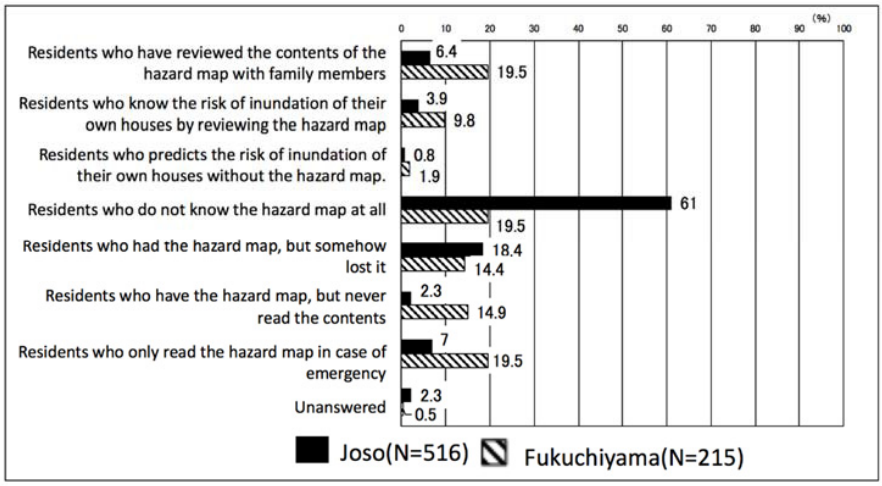

Fig. 8. Comparison of the Awareness of the Hazard Map between Joso Residents and Fukuchiyama Residents.

Fig.9 shows that the comparison of the residents in Joso and Fukuchiyama who decided a flood shelter. 52% of the residents in Fukuchiyama have the steady evacuation site, and so do 26% in Joso.

Moreover, Fig.10 shows that the comparison of whether the residents in Joso and Fukuchiyama know the word "refuge judgment water level". 47% of residents in Fukuchiyama know the word "refuge judgment water level", and 22% in Joso.

From these results, Fukuchiyama residents have higher awareness of disaster convention than Joso residents. One of the reason why Fukuchiyama has the higher awareness of disaster convention is that the disaster occurred in 2013 is still fresh in their minds.

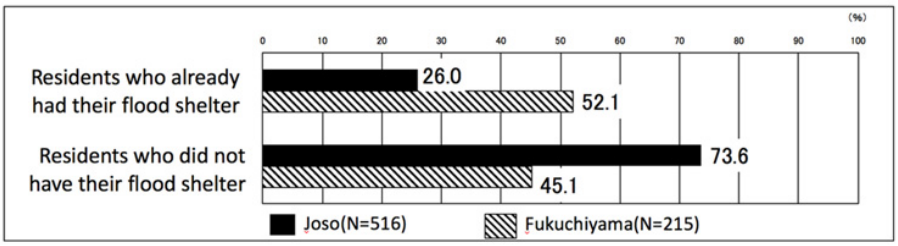

Fig. 9. Comparison of the residents in Joso and Fukuchiyama who decided a flood shelter.

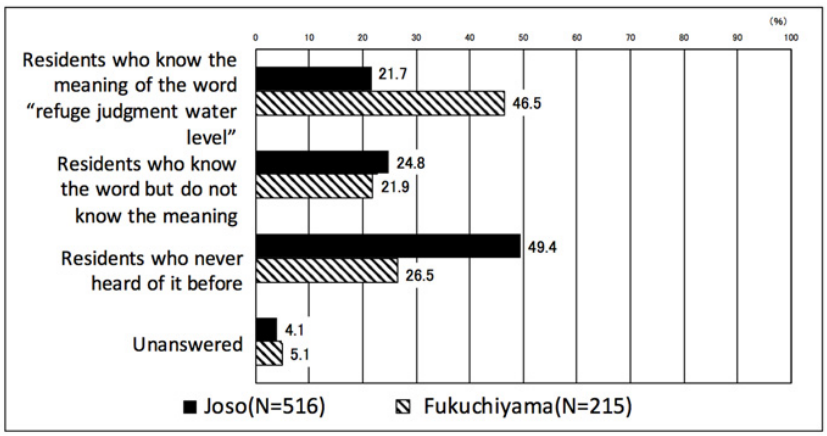

Fig. 10. Comparison of the Understanding of "Refuge Judgment Water Level" between Joso Residents and Fukuchiyama Residents.

5.3 The ideal timing for providing the disaster information in Fukuchiyama

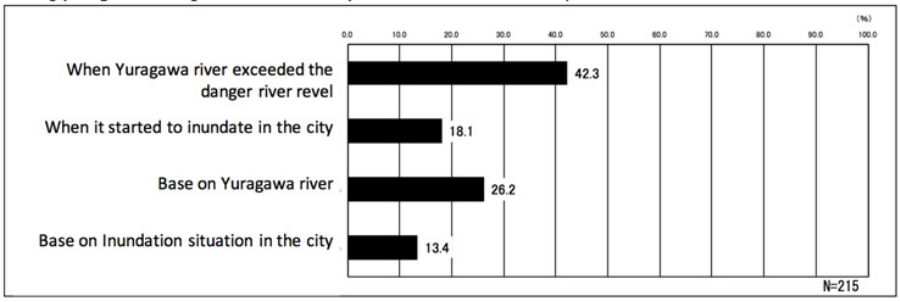

Fig. 11. The ideal timing for providing the disaster information in Fukuchiyama.

Fig. 11 shows the ideal timing for providing the disaster information in Fukuchiyama. About 42% of Fukuchiyama residents answered "When Yuragawa river exceeded the danger river revel". And about 26% of the residents answered "Base on Yuragawa river", it means that residents want to gain the disaster information by the timing that is decided by the Yuragawa river level. From free answer, residents recognize the flooding risk by getting the information about river level. From this results, Fukuchiyama residents tend to care the information about the river level.

6. Summary

From *5.1*, Residents who answered "Evacuation decision-making in 2014 was affected by flood experience in 2013." tend to evacuate to shelters rather than to stay at home. the most numerous reason why those residents, who answered "Evacuation decision-making in 2014 were affected by flood experience in 2013.", evacuate to shelter is "The house was going to be inundated" (about 33%). Therefore, residents who answered "Evacuation decision-making in 2014 was affected by flood experience in 2013." tend to evacuate before flooding because they thought house was going to be inundated. We can assume that the experience of flood is important factor for evacuation decision-making at the time of flood.

In *5.2*, we conduct the comparison of awareness of flood disaster, summary of results are shown below. The number of Fukuchiyama residents who checked the hazard map is about five times larger than Joso, the number of Fukuchiyama residents who decided the flood shelter is about 2 times larger than Joso, and the number of Fukuchiyama residents who knew "refuge judgment water level" is about 2 times larger than Joso. We can assume that residents in Fukuchiyama are more aware of disaster prevention than ones in Joso. The residents in Fukuchiyama are more prepared for flood because they have experienced flood last year. Moreover, there was a lot of answers, which says residents were worried about Kokaigawa river rather than Kinugawa river. 64 % of the residents who have undergone inundation was caused by Kokaigawa river 30 years ago, that could lead us to estimate that they did not think about the flooding risk of Kinugawa river.

We investigate the ideal timing for providing the disaster information in Fukuchiyama in *5.3*. Fukuchiyama residents tend to care the information about the river level. One of the reason why Fukuchiyama residents tend to care the information about the river level is, as mention above, Fukuchiyama residents are more prepared for flood than Joso.

To prevent disaster, the residents should utilize the hazard map practically. Although the percentage of acknowledgement of hazard map in Joso is low, hazard map should be a tool for the residents to communicate with their administration. Hazard map should be an interactive communication tool, just spreading is not enough.

From here on, in order to examine the necessary information and the best timing for evacuation, we are planning to carry out the flood analysis that takes into account the tributaries in addition to the main river.

References

[1] Restoration Status and Flood Damage on a Heavy Rain in Kanto and Tohoku Regions, September, Kanto Regional Development Bureau, Ministry of Land,Infrastructure, Transportation and Tourism.
[2] 豪雨の災害情報学, Motoyuki USHIYAMA.
[3] Toshitaka KATADA, Makoto KODAMA, Junsaku ASADA:Resarch on Aquision of Disaster Information and Evacuation and Evacuation Behavior in Heavy Rainfall Disaster in Tokai District, Advances in River and Engineerling, No.7, pp.155-160, 2001.
[4] Kenji TAKAO, Tadahiro MOTOYOSHI, Teruko SATO, Kami SEO, Saburo IKEDA, Influence of the Flood Disaster Experience and the Threat of Food Disaster on Preparedness-The Tokai Flood Disaster Case-, National Research Institute for Earth Science and Disaster Prevention, No.63, Jun 2002.
[5] Ministry of Land, Infrastructure, Transport and Tourism , River Bureau:Location information about flood and inundation.
[6] Kenji TAKAHASHI:「水防法及び土砂災害警戒区域等における土砂災害防止対策の推進に関する法律の一部を改正する法律について」, Jun 2005, pp31-45.
[7] Ministry of Land, Infrastructure, Transport and Tourism, Division of flood control:Flood Hazard Mapping Manual.
[8] Japan society for natural disaster science:Dictionary of disaster, Tsukiji bookkstore, pp.310.
[9] The general insurance association of japan, Nomura research institute, Research on the current and task of the hazard maps.